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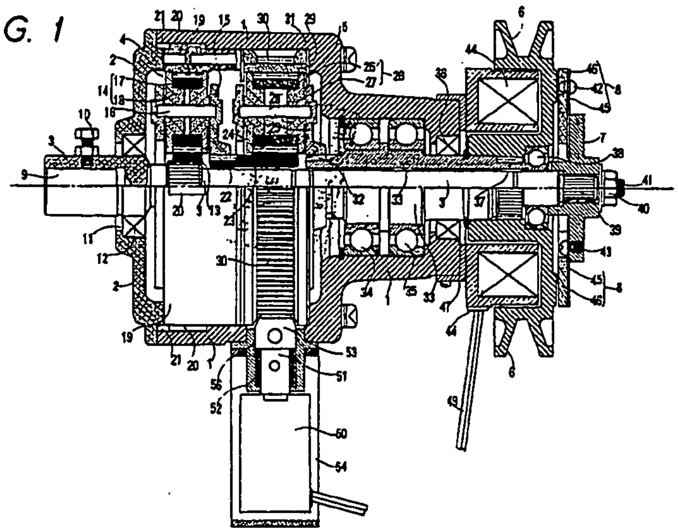
(54) Apparatus for changing the speed.

(57) An apparatus for changing the speed comprises an input shaft (3), several planetary gear units (4, 5), output rotor (6), a rotating disc (8) and a casing (1). The planetary gear units (4, 5) are connected together. A sun gear of the first unit (4) is connected to the input shaft (3) and a carrier of the last unit (5) is connected to the output rotor (6). An internal gear (29) of one of planetary gear units (5) can rotate in the casing but can be stopped by an internal gear stopper device (50, 53). The input shaft (3) is connected to a rotating disc (8). The rotating disc (8) can be brought into contact with the output rotor (6) by a disc-contacting device (44). The disc-contacting device (44) and the internal gear stopping device (50, 53) are driven in a complementary manner. When the internal gear stopping device (50, 53) is excited and the disc-contacting device (44) is unexcited, the output rotor rotates at low speed. When the disc-contacting device is excited and the internal gear stopper device is unexcited, the output rotor rotates at high speed. The apparatus may be used to drive a drum type electric washing machine.

FIG. 1



APPARATUS FOR CHANGING THE SPEED

This invention relates to an apparatus for changing the rotation speed at two levels both clockwise and counterclockwise by using planetary gear units.

A new type of electric washing machines has been proposed. We name it a "drum type " of washing machine. It has a drum which rotates around a horizontal axis unlike the conventional washing machine with a drum which rotates around a vertical axis. We now call the drum of the former a " vertical drum ", because the rotation plane of drum is a vertical plane. When we throw the washing and cleaning material in the vertical drum, shut the cover and turn on the switch, all processes of laundry-washing, rinsing, dehydrating and also drying - are automatically done in succession by changing the rotation speed of the drum in two states. In the washing and rinsing processes, the vertical drum rotates at a low speed with water alternatively in both directions - clockwise and counterclockwise. In the dehydrating process, the vertical drum rotates at a high speed without water in one direction. In the drying process, the drum rotates at the low speed under appliance of heater without water in both direction or in one direction.

In comparison with the conventional electric washing machine, the drum-type washing machine has the advantages which can complete laundry including drying process in the drum and spare water in the washing and rinsing processes.

The drum type of electric washing machine requires two different rotation speeds of the drum according to the processes of laundry. In addition, it is preferable that the drum can rotate both in a clockwise direction and in a counterclockwise direction. Thus in the drum type of washing machine, the drum is required to rotate at two different speeds both clockwise and counterclockwise.

For this purpose, an apparatus for changing speed which comprises a motor with convertible number of poles (four poles in the washing process and two poles in the dehydrating process), a centrifugal clutch and a reduction gear was invented. Namely this apparatus can select two states of transmission ; one is the state where the motor shaft is connected by a reduction gear to the output shaft and the other is the state where motor is directly connected to the output shaft. Either of two states is selected by two clutches.

However this apparatus requires at least two clutches for converting speed. Especially the clutch which connects the carrier of the reduction gear with the output shaft has very complicated structure. Furthermore, in the case of high speed rotation, the drum can rotate only to one direction, because a centrifugal clutch which is inherently unilateral connects the motor shaft to the output shaft. Thus the drum cannot rotate both clockwise and counterclockwise in the case of high speed rotation.

Japanese Patent Laying Open NO. 57-65424 (April 21, 1982) has proposed an apparatus which can convert the rotation speed at two stages by changing the direction of rotation. This apparatus uses a ratchet which has also an inherently unilateral character. For example the rotation torque can be transmitted only clockwise in the high speed state and counterclockwise in the low speed state. It can not be used to the driving device of the drum type of washing machine, because it requires a double-unilateral character.

Japanese patent Laying Open NO.58-24643 (Feb. 14, 1983) has proposed another apparatus which can convert the rotation speed using a planetary gear unit. The internal gear is fixed to the casing. The carrier is not connected to the output shaft directly, but intermediated by a collar which can be moved in an axial direction on the surface of the output shaft. When the collar is moved toward the input shaft, the collar connects the output shaft with the input shaft and the output shaft rotates fast. When the collar is moved toward the output shaft, the collar connects the output shaft with the carrier of the planetry gear unit and the output shaft rotates slowly.

The purpose of this invention is to provide an apparatus for changing the speed which can transmit rotation torque both clockwise and counterclockwise both at a high speed level and at a low speed level.

The apparatus of this invention comprises an input shaft, an output rotor, one planetary gear unit or a plurality of planetary gear units being successively connected and being arranged between the input shaft and the output rotor.

In the case of the successively connected planetary gear units, a carrier of a unit is connected to a sun gear of the next unit, the sun gear of the first unit is connected to the input shaft and the carrier of the last unit is connected to the output rotor. One of the planetary gear units has an internal gear which can choose alternatively one of two states - a free rotation state and a rest state in a casing. The internal gears of other planetary gear units are fixed to the casing.

In the case of one planetary gear unit, the sun gear is connected to the input shaft, the carrier is connected to the output rotor, and the internal gear can choose one of two states - a free rotation state and a rest state in the casing.

The input shaft pierces center holes of the planetary gear units or the output rotor. A rotating disc is

mounted on the input shaft in the neighborhood of the output rotor. Furthermore a disc-contacting device is installed for bringing the rotating disc into contact with the output rotor in a mechanical manner or a magnetic manner. The carrier of the last planetary gear unit is connected with the output rotor without intermediate clutch.

The internal gear which is permitted to select the free rotating state or the rest state is supported rotatably in the casing. To distinguish the unit having the internal gear, the unit is now called a " converter unit " and the internal gear is called a " converter Internal gear ". An internal gear stopping device is installed for braking the internal gear by an adequate means from the side. Then the disc-contacting device and the internal gear stopping device are driven in a complementary manner in the apparatus above-mentioned. Namely when the internal gear stopping device is driven, the disc-contacting device is at rest and when the disc-contacting device is driven, the internal gear stopping device is at rest.

Therefore, when the converter internal gear is braked by driving the internal gear stopping device and the disc contacting device is at rest, the output rotor rotates at a low speed level either clockwise or counterclockwise. On the other hand, when the converter internal gear is permitted a free rotation by releasing the internal gear stopping device and the disc contacting device is driven, the output rotor rotates at a high speed level either clockwise or counterclockwise.

Any cases other than the two cases are forbidden. Namely, it is forbidden that the free rotation of the converter internal gear is simultaneous with the disc-contacting device at rest. Similarly it is also forbidden that the rest state of the converter internal gear is simultaneous with the work of the disc-contacting device.

The functions of the two cases will now be explained.

(a) Case of low speed rotation

The converter internal gear is braked and the disc-contacting device is released. In this case; the converter unit plays only a role of a reduction gear. The reduction rate of the converter unit is designated by R_0. The reduction rates of other planetary units are designated by R_1 . R_2. ...., R_n. The rotation speed of the input shaft is denoted by A and that of the output rotor is denoted by B. the relation of A to B is given by

$$B = \frac{1}{R_n \cdots\cdots\cdots\cdots R_1 \,.\, R_0} A \qquad (1)$$

This means that the output rotor rotates at a low speed and the direction of rotation of the output rotor is same with the direction of the input shaft.

Even in this case, the rotating disc is rotating at a high speed being equal to the rotation speed A of the input shaft. But the difference of the rotation speeds incurs no difficulty, because there is an air gap between the rotating disc and the output rotor, even though the gap is narrow.

(b) Case of high speed rotation

The converter internal gear is permitted free rotation by releasing the internal gear stopping device and the disc-contacting device is driven.. The rotating disc which is rotating at an input rotation speed A is kept in contact with the output rotor. Then the output rotor rotates at a speed A. Namely

B = A (2)

Therefore the output rotor rotates at a high speed. What enables the output rotor to rotate freely is the free rotation of the converter internal gear.

However the free rotation speed of the internal gear of the converter unit is considerably high. The reason will be explained. There are a plurality of planetary gear units. The units positioned before the converter unit are designated by numerals 1, 2, ..., and k.

The product Q of the reduction rates R_1, R_2, ... R_k of the forward units is defined by

$$Q = \prod_{i=1}^{k} R_i \qquad (3)$$

The other units positioned after the converter unit are designated by numerals (k+l), ..., and n. The product T of the reduction rates R_{K+l} ...... and R_n of the rear units is written as

$$T = \prod_{i=k+1}^{n} R_i \qquad (4)$$

The rotation speed of the sun gear of the converter unit is denoted by S_0. This rotation is generated by dividing the input rotation by the reduction rate Q. Thus

$$S_0 = \frac{A}{Q} \qquad (5)$$

The rotation speed of the converter carrier is denoted by C_0. This is obtained by multiplying the output rotation B by T. Then

$$C_0 = TB = TA \qquad (6)$$

In the converter unit, the sun gear rotates at a low speed and the carrier rotates at a high speed. By the action of the two gears, the internal gear rotates also at another high speed. This is a rather abnormal state, because a sun gear rotates faster than a carrier in a normal planetary gear assembly. Thus it is now calculated how fast the internal gear rotates in the casing.

Z_s and Z_i denote the tooth numbers of the sun gear and the internal gear respectively. The rotation speeds of the sun gear, the carrier and the internal gear are designated by S_0, C_0, I_0. There is a relation between the variables.

$$S_0 Z_s + I_0 Z_i = (Z_s + Z_i) C_0 \qquad (7)$$

This is a fundamental equation of a planetary gear unit. Substituting Eq.(5) and Eq.(6) into Eq.(7), we obtain the rotation speed of the internal gear of the converter unit.

$$I_0 = \left\{ \frac{Z_s}{Z_i} \left(T - \frac{1}{Q} \right) + T \right\} A \qquad (8)$$

This is a considerably high speed of rotation. Then the bearing device of the converter internal gear in the casing should be designed with sufficient consideration.

An embodiment of this invention will be now explained with the help of drawings.

FIG.1 is a vertically sectioned front view of an apparatus for changing the speed as an embodiment of this invention.

FIG.2 is a right side view of the embodiment.

FIG.3 is a left side view of the embodiment.

FIG.4 is a partially sectioned front view of another embodiment of the disc contacting device.

This apparatus comprises a casing consisting of a casing body (1) and a cover (2), an input shaft (3), a first planetary gear unit (4) and a second planetary gear unit (5) which are mounted in the casing. The casing body (1) is a stepped cylinder having a cylindrical part with a wider inner diameter and another cylindrical part with a narrower inner diameter. In the wider cylindrical part, the first planetary gear unit (4) and the second planetary gear unit (5) are mounted in succession so as to coincide the center axes with each other. The first planetary gear unit (4) is fixed to the casing. But the second planetary gear unit (5) is rotatably mounted in the casing.

The input shaft (3) fully pierces the center axis of the casing. Near the end of the input shaft projecting out of the casing, an output rotor (6) is mounted so as to be permitted a free rotation relative to the input shaft (3).

On the outer side of the output rotor (6), a rotating hub (7) is mounted on the end of the input shaft (3). Furthermore a rotating disc (8) is attached to the rotating hub (7). The rotating disc (8) is faced with the output rotor (6) by a narrow air gap.

On an input end of the input shaft (3), a connection bore (9) is perforated in the axial direction. A motor shaft (not shown in the figures) shall be inserted into the connection bore (9) and fixed by a fixation bolt (10). An opening (11) is perforated at the center of the cover (2). An oil seal (12) is fitted between the opening (11) and the input shaft (3).

The first planetary gear unit (4) comprises a sun gear (13) at the center, three or four planetary gears (14) meshing with the sun gear (13), a carrier (15) and an internal gear (19) meshing with the planetary gears (14). The planetary gears (14) are rotatably supported by planetary shafts (16) whose ends are held by the carrier (15). In this example, the planetary gear consists of a planetary gear part (17) in the middle and two planetary discs (18) and (18) supporting the planetary gear part (17) from the sides. The outer diameter of the planetary gear part (17) is bigger than the diameter of the tooth edge circle of the planetary gear part (17).

The internal gear (19) meshing with the planetary gears (14) has a plurality of radial protrusions (20) on the outer surface for fixing it in the casing. In accordance with the shape of the internal gear (19), longitudinal inner grooves (21) are shaped on the inner surface of the casing body (1). The internal gear (19) is fixed in the casing by fitting the radial protrusions (20) into the inner grooves (21) of the casing. The first planetary gear unit (4) acts as a reduction gear.

A spline (22) is shaped on an output hole of the carrier (15) of the first planetary gear unit (4). A connecting shaft (23) is used to transmit the rotation from the first planetary gear unit (4) to the second planetary gear unit (5). The connecting shaft (23) is a cylinder having a splined end and a gear shaped end. The input shaft (3) also pierces the connecting shaft (23). The input shaft (3) and the connecting shaft (23) are in a coaxial relation. Owing to a narrow air gap therebetween, relative rotation is allowed between the input shaft (3) and the connecting shaft (23). The splined end of the connecting shaft (23) is inserted into the spline (22) of the carrier (15). On the other hand the gear shaped at the end of the connecting shaft (23) is a sun gear (24) of the second planetary gear unit (5).

The second planetary gear unit (5) comprises planetary gears (26) meshing with the sun gear (24), a carrier (25) rotatably supporting the planetary gears (26) by planetary shafts (28) and an internal gear (29) meshing with the planetary gears (26). Like the first planetary gear unit (4), the planetary gear (26) consists of a planetary gear part (26') in the middle and two planetary discs (27) and (27) holding the planetary gear part (26') from both sides. The outer diameter of the planetary discs (27) is larger than the diameter of the tooth edge circle of the planetary gear part (26').

The internal gear (29) has smooth sliding surfaces (31) and (31) with large outer diameters on sides and a rugged surface having outer teeth (30) with a small outer diameter in the middle. The sliding surfaces (31) and (31) are kept in contact with the inner surface of the casing. However, the sliding surfaces (31) are not fixed to the casing and the internal gear (29) is permitted to rotate freely in the casing body (1). The sliding surfaces (31) and the smooth inner surface of the casing play a role of bearing. This corresponds to a slide bearing. But this is able to be replaced by other kinds of bearing e.g. ball bearing, roller bearing etc.

The output hole of the carrier (25) is shaped into a spline (32). A splined end of a connecting cylinder (33) is inserted in the spline (32) of the carrier (25). The connecting cylinder (33) is a long cylinder for coupling the carrier (25) with the output rotor (6). The connecting cylinder (33) is rotatably installed in a position being coaxial to the input shaft (3). There is an air gap between the outer surface of the input shaft (3) and the inner surface of the connecting cylinder (33). Then both the connecting cylinder (33) and the input shaft (3) independently rotate. The connecting cylinder (33) is rotatably supported by bearings (34)

and (35) in the small cylindrical part of the casing.

An oil seal (36) is equipped between an opening of the casing body (1) and the connecting cylinder (33) at the portion projecting from the casing. The inner space of the casing is tightly closed by two oil seals (12) and (36). Oil shall be filled into the casing for lubrication.

The end of the connecting cylinder (33) has a splined surface. The splined surface is inserted into a splined hole (37) of the output rotor (6). Thus the carrier (25) is coupled with the output rotor (6) by the connecting cylinder (33).

A bearing (38) is mounted between a stepped part of the inner surface of the output rotor (6) and the input shaft (3). An inner lace of the bearing (38) is in contact with the rotating hub (7) but is distanced from the connecting cylinder (33) by a small gap. An outer lace of the bearing (38) is in contact with the output rotor (6).

The rotating hub (7) has a central hole on which a spline is shaped. The fore end with a spline (39) of the input shaft (3) is inserted into the splined hole of the rotating hub (7). The rotating hub (7) is fixed by a nut (40) fitted around a thread part (41) shaped on the end of the input shaft (3).

A rotating disc (8) is annexed to the rotating hub (7) by screws (43). The rotating disc (8) consists of a thin elastic plate (45) and an iron disc (46). The abovementioned screws (43) couples the elastic plate (45) with the rotating hub (7). Screws (42) unify the iron disc (46) with the elastic plate (45) near the periphery. As shown well in FIG.2, the distances of the screws (42) and and the screws (43) which connect the elastic plate (45) to the iron disc (46) and to the rotating hub (7) are so long that the elastic plate (45) is likely to bend inward by a weak axial force applied on the iron disc (46). However the elastic plate (45) has angular rigidity enough to transmit torque from the rotating hub (7) to the iron disc (46), because the elastic plate (45) is shaped like a wave.

The output rotor (6) has a circular cavity on the inner side. There is a ring-shaped electromagnet (44) in the cavity. The electromagnet (44) is mounted on a side surface of the casing body (1) by a supporting plate (47) and screws. The electromagnet (44) is separated from the inner surface of the output rotor (6) by a narrow air gap. The electromagnet (44) is always at rest, because it is mounted on the casing. The output rotor (6) rotates either at a high speed level (same with the input shaft (3)) or a low speed level. The rotating disc (8) always rotates at a high speed level. The narrow air gaps enable the three parts to rotate at different speed levels. The electromagnet (44) consists of a ferromagnetic core and coil wound around the core. Electric current shall be applied to the coil through lead wires (49). This electromagnet (44) constitutes a disc-contacting device for keeping the rotating disc (8) in contact with the output rotor (6). When no current is supplied to the coil, the electromagnet (44) is not excited and the rotating disc (8) is separated from the output rotor (6).

But when the current is supplied to the coil, the electromagnet (44) is excited and magnetized. The magnetic force attracts the iron disc (46) of the rotating disc (8). The thin elastic plate (45) elastically deforms toward the electromagnet (44). The iron disc (46) is brought into contact with the side of the output rotor (6). Strong friction force occurs between the iron disc (46) and the output rotor (6). This contact is kept by the magnetic force.

The output rotor can also be made of non-ferromagnet material. But it is desirable for the output rotor (6) to be made of ferromagnetic material e.g. iron, steel, nickel, cobalt or ferromagnetic alloys. If the output rotor is ferromagnetic, a magnetic force reinforces the contact between the output rotor (6) and the iron disc (46) in addition to the friction force. Owing to the friction force and the magnetic force, the output rotor (6) rotates at a high speed with the rotating disc (8).

Now a device for stopping the internal gear is now explained. A solenoid (50) is fixed at the position of the second planetary gear unit (5) on the outer surface of the casing by a bracket (54) and screws. A bore is perforated on the casing at a side of the second planetary gear unit (converter unit). The solenoid (50) is equipped with a plunger (51) which moves in a radial direction of the casing. In this example the solenoid (50) is one of conventional unipolar ones. The plunger (51) is pushed inward in the radial direction by an elastic force of the spring (52). A stopper piece (53) is fitted to the edge of the plunger (51). A guide (56) is mounted at the hole of the casing. The stopper piece (53) slides in the guide (56). The stopper piece (53) penetrates the casing through the guide (56). The stopper piece (53) meshes with the outer tooth (30) on the internal gear (29) of the second planetary gear unit when the plunger (51) is pushed forward. The meshment forbids the rotation of the internal gear (29). When the plunger (51) is pulled backward, the stopper piece (53) separates from the outer tooth (30) and the internal gear (29) rotates freely

In this embodiment, a conventional unipolar solenoid is used to move the plunger up and down. When electric current is supplied to the coil of the solenoid (50), the plunger (51) recedes backward and the stopper piece (53) is disengaged from the outer tooth (30). Otherwise, when no electric current is supplied to the solenoid, the plunger (51) is pushed forward by the elastic force of the spring (52) and the stopper

piece (53) meshes with the outer tooth (30) of the internal gear (29). The internal gear (29) is kept in a rest state by the elastic force of the spring (52). Namely the solenoid (50) and the stopper piece (53) constitute the internal gear stopping device.

Of course, other types of solenoids are available for the internal gear stopping device. For example, another internal gear stopping device is constructed by using a unipolar solenoid in a reverse disposition. Namely in the device when the electricity is supplied to the solenoid, the plunger extends till the stopper piece (53) meshes with the outer tooth (30). And when no electricity is supplied, the plunger is pulled by a spring and the stopper piece (53) separates from the outer tooth (30). This example has an advantage that the rest state of the internal gear is more stable, because the meshment between the stopper piece (53) and the outer tooth (30) is kept by the magnetic force induced by electric current which is larger than the elastic force of the spring.

Furthermore another internal gear stopping device can be assembled by a bipolar self holding solenoid which has not a spring but has a permanent magnet. The plunger is driven forward or backward by supplying electric current into a coil or coils to a front direction or reverse direction in a moment. The plunger can adopt two stable states - front state and back state. The magnetic force of the permanent magnet keeps the plunger both in the two stable states instead of the springs. Although bipolar self holding solenoids are rather expensive, they are more appropriate to a part of the internal gear stopping device, because the magnetic force is stronger than the elastic force of springs and electricity can be saved.

Besides solenoids, a motor with a reduction gear is also available for constructing the internal gear stopping device. In this case, the stopper piece moves either forward or backward according to the rotation direction of the motor.

In any case, the state in which the stopper piece (53) separates from the outer tooth (30) is called an unexcited state and the state in which the stopper piece (53) meshes with the outer tooth is called an excited state.

The function of the apparatus will now be explained.

In order to rotate the output rotor (6) at a low speed level, the switch of the solenoid (50) is turned off and the electromagnet (44) is left unexcited. The stopper piece (53) pushed by the spring (52) meshes with the outer tooth (30). The internal gear (29) is at rest. A narrow air gap separates the iron disc (46) from the output rotor (6), because the electromagnet (44) is unexcited. " A " denotes the rotation speed of the input shaft. The rotation speed of the carrier of the first planetary gear unit (4) (reduction rate : R_1) is A/R_1. The second planetary unit (5) functions as a reduction gear(reduction rate : R_o), because the internal gear is fixed. The rotation speed of the carrier of the second planetary gear unit (5) is A/R_1R_o. The rotation speed " B " of the output rotor (6) is equal to it, because the output rotor (6) is coupled with the carrier of the second planetary gear unit (5).

$$B = \frac{A}{R_1 \ R_o} \qquad (9)$$

Namely, the output rotor rotates at a low speed.

On the contrary in order to rotate the output rotor (6) at a high speed level, the switch of the solenoid (50) is turned on and the electromagnet (44) is excited. The stopper piece (53) is pulled back and separated from the outer tooth (30). The internal gear (29) of the second planetary gear unit (5) can rotate freely. The iron disc (46) is attracted by the electromagnet (44) into contact with the output rotor (6). The output rotor (6) rotates together with the rotating disc (8) by the friction force and the magnetic force. As the rotating disc (8) is fitted to the input shaft (3), the rotating speed " B " of the output rotor (6) is equal to the speed of the input shaft (3).

$$B = A \qquad (10)$$

Thus the output rotor (6) rotates at a high speed. In this case, the internal gear of the second planetary gear unit (5) (converter unit) rotates considerably fast. Because the rotation speeds of the sun gear and the carrier are A/R_1 and A respectively, substituting $T = 1$ and $Q = R_1$, we obtain the rotation speed I_o of the internal gear

$$I_O = \left\{ \frac{Z_s}{Z_O} \left(1 - \frac{1}{R_1} \right) + 1 \right\} A \qquad (11)$$

As mentioned before, in this case the internal gear rotates faster than the sun gear.

In principle, if more than two planetary gear units are used, anyone of units can be chosen as a converter unit in which the internal gear is rotatably mounted in the casing. But it is preferable to select the last unit to be a converter unit, because the free rotations of the internal gears are more moderate. The reason is now explained.

It is assumed that the first planetary gear unit is chosen as the converter unit. The internal gear of the first unit can select either a free rotation state or a rest state, and the internal gear of the second unit is fixed. Then the rotation speed I'_o of the internal gear of the first unit is derived from Eq.(8) by substituting $T = R_1$ and $Q = 1$,

$$I'_O = \left\{ \frac{Z_s}{Z_1} (R_1 - 1) + R_1 \right\} A \qquad (12)$$

As R_1 is larger than 2 without fail, Eq.(12) is larger than Eq.(11). The rotation speed of the internal gear is faster in the case of the first converter unit than in the case of the second converter unit. This result teaches that it is preferable to select the last unit as a converter unit to decrease the free rotation speed of the internal gear.

As mentioned before, when the rotating disc (8) is in contact with the output rotor (6), the internal gear of the converter unit must rotate freely. To accomplish this purpose, the internal gear stopping device and the disc rotating device must simultaneously be driven and undriven in a complementary manner. However the simultaneity is not so rigorous. Even if the complementary motions of the two devices are slightly discrepant, this apparatus will work well, because a slippage occurs between the output rotor (6) and the rotating disc (8). The slipping would alleviate the shock acting upon the teeth of the gear units.

In FIG.2, the iron disc (46) is able to the replaced by some ferromagnetic material e.g. nickel, cobalt or alloys (Fe - Ni, Fe - Cr etc.) FIG.4 shows another embodiment of a disc-contacting device. A rotating disc (8) is a dish-like rigid body fitted to the input shaft (3). Relative rotation is forbidden but axial displacement is permitted between the rotating disc (8) and the input shaft (3). A spring (61) pushes the rotating disc (8) outward along an axial line. A solenoid (60) having a plunger (62) is installed at a point near the rotating disc (8). A roller (63) is supported at the front end of the plunger (62). When the plunger (62) is expanded by exciting the solenoid (60), the roller (63) brings the rotating disc (8) in contact with the output rotor (6). The rotating disc (8) has a plurality of protrusions (65) on a side contact wall. In accordance with the protrusion (65), cavities (64) are bored on a side wall of the output rotor (6). When the rotating disc (8) is brought into contact with the output rotor (6), the protrusions (65) soon penetrate the cavities (64). Then the output rotor (6) rotates together with the rotating disc (8) except for initial slippage in a short time.

A disc-contacting device other than ones shown in FIG.1 and FIG.4 is also available. For example a device can also be constructed by using shape memory alloys. In this device, the elastic plate (45) in FIG.1 is replaced by a thin shape memory alloy (e.g. Ni - Ti SMA), and a heater for heating the plate is installed near the rotating disc (8). The shape memory alloy has a critical temperature above and below which the shape of the alloy changes. Thus a distorted shape of the plate pushing the side of the output rotor (6) has been memorized above the critical temperature. When the heater is left unexcited, the plate does not deform and the rotating disc separates from the output rotor. When the heater is driven, the shape memory alloy deforms to push the output rotor (6).

The advantages of the invention is now explained.

(1) This apparatus can convert the rotation speed of the output rotor at a high speed level or at a low speed level.

(2) Both directions of rotation - clockwise and counterclockwise - can be transmitted.

(3) Because planetary gear units are used as reduction gears, a motor, an input shaft and an output rotor are arranged along a same axial line. This structure enables us to spare space and widen the freedom of design.

(4) This apparatus of the invention is one of the most appropriate driving device for the drum type of electric washing machines.

Claims

1. (1) An apparatus for changing the speed comprising an input shaft for receiving an input rotation, a plurality of planetary gear units having a sun gear, planetary gears meshing with the sun gear, an internal gear meshing with the planetary gears and a carrier for rotatably supporting the planetary gears and being arranged in an axial direction around the input shaft : the carrier of a unit being connected to the sun gear of the next unit : the sun gear of the first unit being connected to the input shaft, an output rotor being mounted around the input shaft without preventing from relative rotation thereof, a casing containing the input shaft and all the planetary gear units, the casing supporting the input shaft and an internal gear of one of the planetary gear units without preventing from rotation and fixing the internal gears of the other planetary gear units, a rotating disc being fixed to the input shaft neighboring to the output rotor, a disc-contacting device for bringing the rotating disc into contact with the output rotor, an internal gear stopping device for stopping the internal gear being rotatably supported by the casing, and a connecting cylinder being pierced by the input shaft for connecting the carrier of the last planetary gear unit with the output rotor, wherein the internal gear supporting device and the disc contacting device are driven in a complementary manner : the internal gear stopping device being driven while the disc-contacting device being rested : the disc-contacting device being driven while the internal gear stopping device being rested, the output rotor rotates at a high speed when the disc contacting device keeps the rotating disc in contact with the output rotor, and the output rotor rotates at a low speed when the internal gear stopping device is driven.

2. (2) An apparatus for changing the speed as claimed in claim 1, wherein the disc-contacting device comprises a rotating hub being fixed to the input shaft, an elastic plate being connected to the fixed to the input shaft, an elastic plate being connected to the rotating hub, a ferromagnetic disc being connected to the elastic plate and an electromagnet being fixed to the casing on a side of the output rotor opposite to the ferromagnetic disc; when the electromagnet is excited, the electromagnet brings the ferromagnetic disc into contact with the output rotor by a magnetic force, the elastic plate bends toward the output rotor and the output rotor rotates at a high speed as fast as the input shaft ; when the electromagnet is unexcited, the electromagnet leaves the ferromagnetic disc separated from the output rotor.

3. (3) An apparatus for changing the speed as claimed in claim 1, wherein the disc-contacting device comprises a rotary disc being fitted to the input shaft, a spring mounted around the input shaft for pushing the rotation disc outward, a solenoid having a plunger, a roller being supported by the plunger for pushing the rotating disc inward, the output rotor having cavities on an outer side surface, the rotating disc having protrusions corresponding to the cavities on a side, the rotating disc being permitted to move in an axial direction on the input shaft ; when the solenoid is excited, the solenoid pushes the roller on the rotating disc inward, the protrusions of the rotating disc are inserted into the cavities of the output rotor, and output rotor rotates at a high speed as fast as the input shaft, when the solenoid is unexcited, the rotating disc is separated from the output rotor.

4. (4) An apparatus for changing the speed as claimed in claim 1, wherein the disc-contacting device comprises a rotating hub being fixed to the input shaft, a side plate made of a shape memory alloy being connected to the rotating hub neighboring to a side of the output rotor and a heater for heating the side plate above the transition temperature ; when the heater being turned on, the side plate pushing the output rotor, the output rotor rotating at a high speed as fast as the input shaft, when the heater being turned off, the side plate separating from the output rotor.

5. (5) An apparatus for changing the speed as claimed in claim 1, wherein the connecting cylinder for connecting the carrier of the last planetary gear unit to the output rotor is supported by bearings to an inner surface of the casing and is fitted by an oil seal at an opening of the casing.

6. (6) An apparatus for changing the speed as claimed in claim 1, wherein the connecting shaft for connecting the carrier of a planetary gear unit to the sun gear of the next planetary gear has a sun gear

part unified therewith.

7. (7) An apparatus for changing the speed as claimed in claim 6, wherein the planetary gear has a planetary gear part having a radius in the middle and two planetary discs having a radius on both sides, the planetary disc being bigger in radius than a tooth edge circle of the planetary gear part, the connecting shaft being supported by the planetary gear parts of the next planetary unit.

8. (8) An apparatus for changing the speed as claimed in claim 1, wherein the internal gear stopping device comprises a solenoid having a plunger which extends or shrinks in a axial direction, a stopper piece attached to the plunger, a guide for keeping the stopper piece moving in the axial direction, a bracket for fixing the solenoid to the casing and an outer tooth being shaped on an outer surface of the internal gear of the planetary gear unit being permitted rotation in the casing ; when the solenoid is excited to one direction, the stopper piece is brought into meshment with the outer tooth of the internal gear and the internal gear is stopped ; when the solenoid is excited to the other direction, the stopper piece separates from the outer tooth and the internal gear is permitted to rotate freely.

9. (9) An apparatus for changing the speed as claimed in claim 8, wherein the solenoid is a unipolar solenoid having a ferromagnetic yoke, a coil and a spring, the spring pushing elastically the plunger to a direction and the coil being electrified pushing the plunger to the other direction.

10. (10) An apparatus for changing the speed as claimed in claim 8, wherein the solenoid is a bipolar self holding solenoid having a ferromagnetic yoke, one or two coils and permanent magnets, the permanent magnets being able to keep the plunger at two points and the coils being electrified displacing the plunger from the point to another point.

11. (11) An apparatus for changing the speed comprising an input shaft for receiving an input rotation, a planetary gear unit having a sun gear, planetary gears meshing with the sun gear, an internal gear meshing with the planetary gears and a carrier for rotatably supporting the planetary gears ; the sun gear being connected to the input shaft, an output rotor being mounted around the input shaft without preventing from relative rotation thereof, a casing containing the input shaft and the planetary gear unit : the casing supporting the input shaft and the internal gear of the planetary gear unit without preventing from rotation, rotating disc fixed to the input shaft neighboring to the output rotor, a disc-contacting device for bringing the rotating disc into contact with the output rotor, an internal gear stopping device for stopping internal gear being rotatably supported by the casing, and a connecting cylinder being pierced by the input shaft for connecting the carrier of the planetary gear unit with the output rotor, wherein the internal gear supporting device and the disc contacting device are driven in a complementary manner : the internal gear stopping device being driven while the disc-contacting device being rested : the disc-contacting device being driven while the internal gear stopping device being rested, the output rotor rotates at a high speed when the disc-contacting device keeps the rotating discs in contact with the output rotor, and the output rotor rotates at a low speed when the internal gear stopping device is driven.

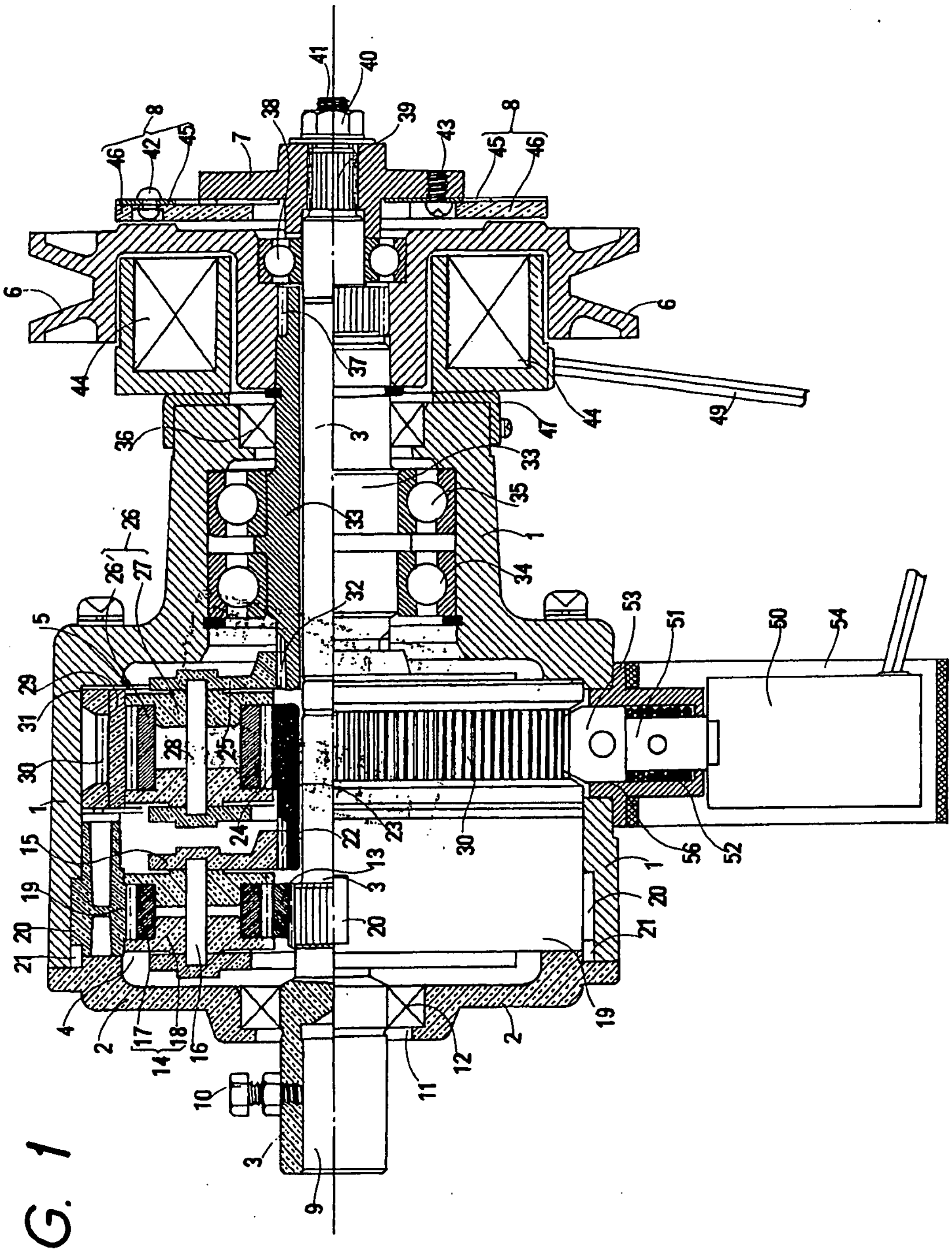


FIG. 1

FIG. 2

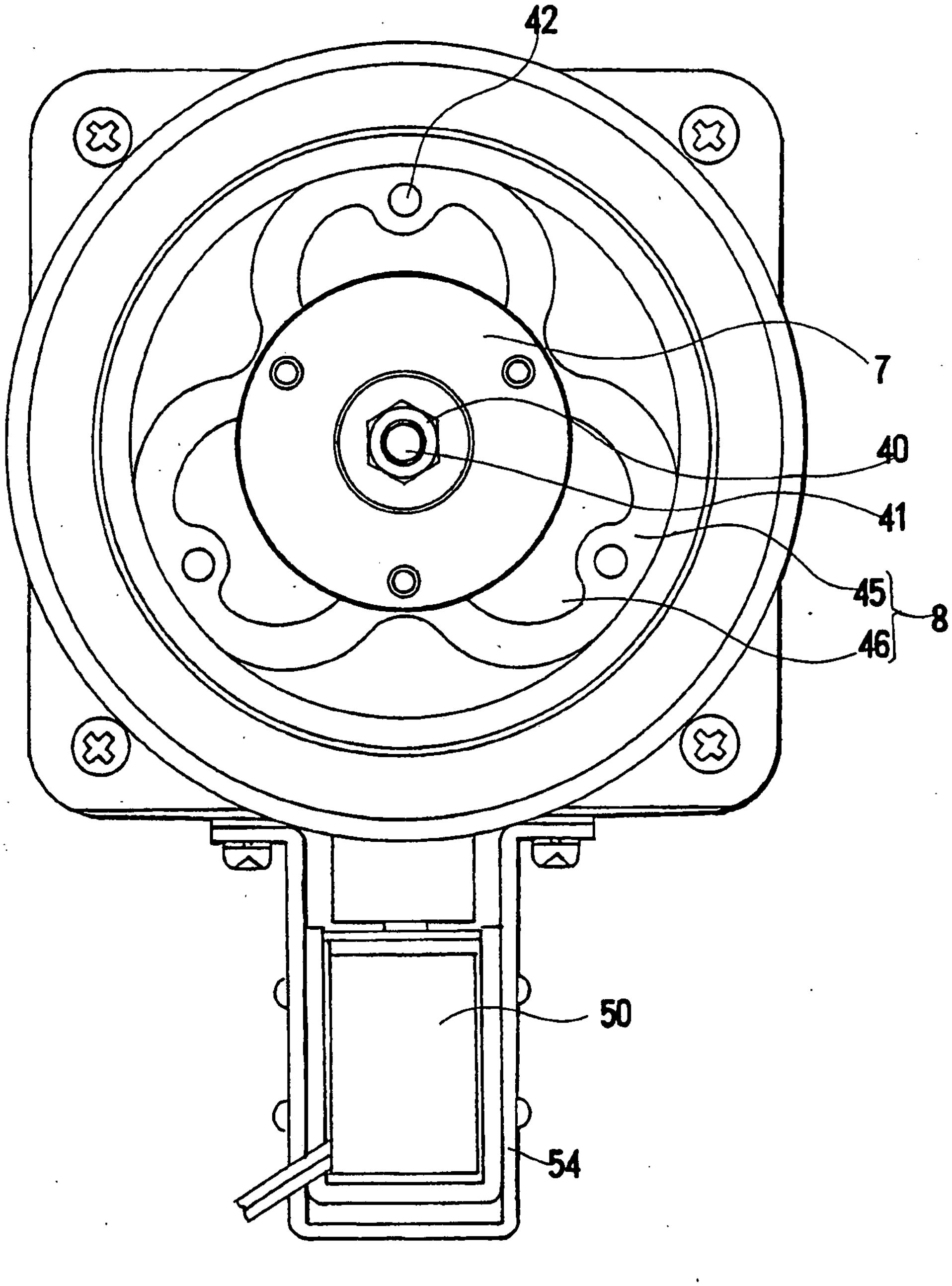
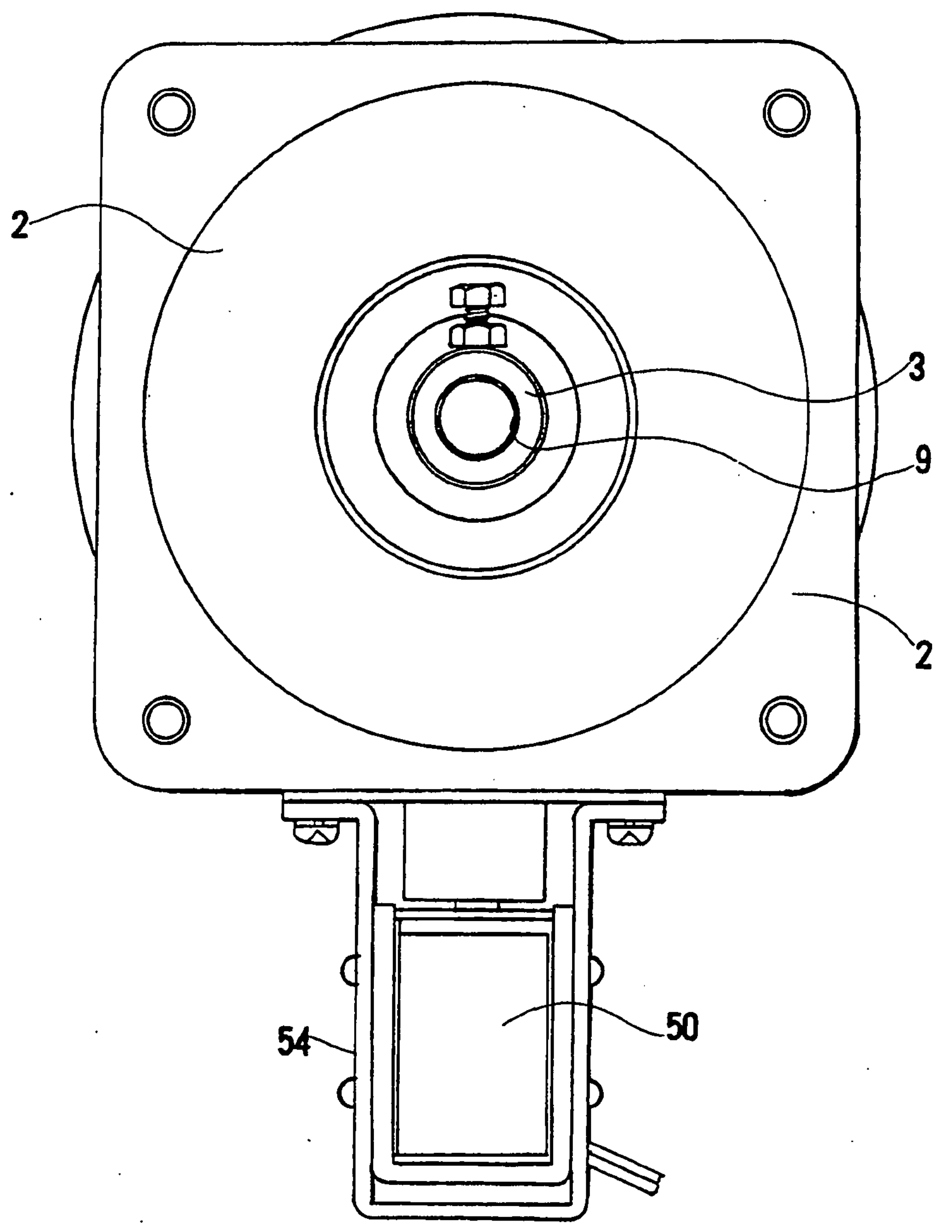


FIG. 3



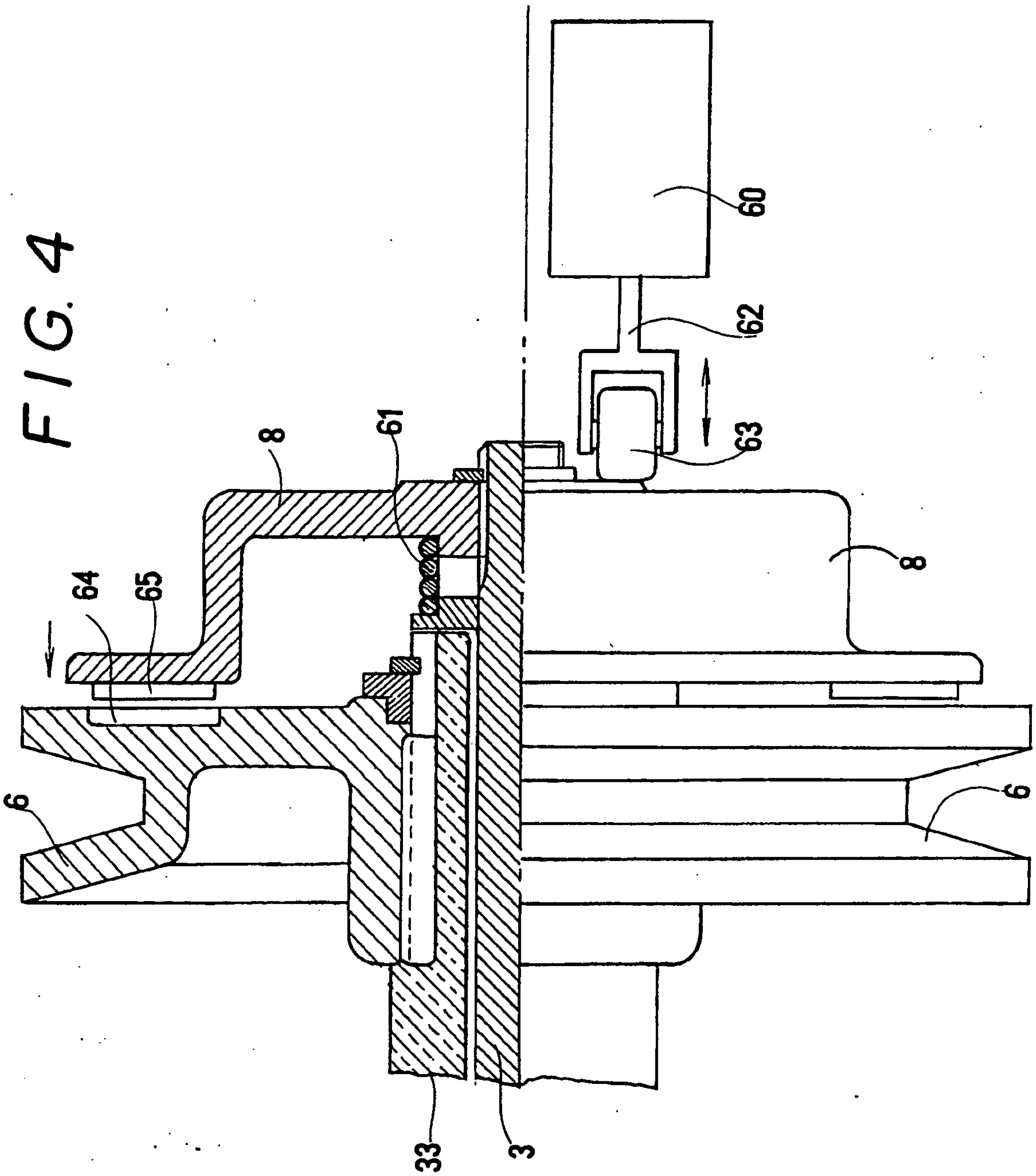


FIG. 4

European Patent Office

EUROPEAN SEARCH REPORT

Application Number

EP 90 31 2636

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.5)
Y,A	US-A-4 706 521 (ANDERSSON ET AL.) * the whole document * - - -	1,6,11,5	F 16 H 3/54
Y	DE-A-3 525 208 (JAPAN STRAGE BATTERY CO. LTD.) * page 11, line 10 - page 12, line 23; figures 1, 5 * - - -	1,6,11	
A	EP-A-0 212 276 (CANADIAN FRAME LTD.) * claim 1; figure 1 * - - -	1,11	
A	EP-A-0 190 415 (CANADIAN FRAM LTD.) * page 3, line 28 - page 4, line 33; figure 1 * - - -	1,3,11	
A	US-A-4 874 973 (MATSUSHITA ET AL.) * column 1, lines 35 - 42; figure 2 * - - -	2	
A	FR-A-1 570 370 (FAUN-WERKE NÜRNBERG KOMMUNALFAHRZEUGE UND LASTKRAFTWAGEN KARL SCHMIDT) * page 1, line 40 - page 2, line 9; figure 1 * - - -	4	
A,D	GB-A-2 103 735 (BORG-WARNER CORP.) * claim 1; figure 1 & JP-A-5824643 * - - -	1,11	**TECHNICAL FIELDS SEARCHED (Int. Cl.5)**
A	DE-A-2 635 616 (EDLER & SOHN) * the whole document * - - - - -	8	F 16 H F 02 B B 60 T F 16 D

The present search report has been drawn up for all claims

Place of search	Date of completion of search	Examiner
The Hague	08 March 91	HELMROTH H.P.

CATEGORY OF CITED DOCUMENTS

X: particularly relevant if taken alone
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